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CHEMICAL & ENGINEERING

NEWS

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Battle shaping up over imports
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News Focus

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Battle Rages over Imports of Fuel Ethanol

In addition to antidumping and countervailing duty suits against Brazil, both the Caribbean Basin Initiative and tariff loopholes figure prominently in the struggle to cut off large-volume imports

Earl V. Anderson, C&EN New York

Fuel-grade ethanol is fueling more than cars, trucks, and tractors in the U.S. It also is fueling a high-octane battle over imports.

The latest beachhead was established earlier this month when the five commissioners of the International Trade Commission voted unanimously that there is a "reasonable indication" that imports of fuel ethanol from Brazil are threatening to cause material injury to the U.S. fuel ethanol industry.

The vote came after a consortium of domestic producers filed an antidumping and a countervailing duty petition against Brazilian fuel ethanol imports. The U.S. producers claim they are being hurt by Brazilian ethanol that is heavily subsidized by the Brazilian government and that is being sold in U.S. markets at less than fair value.

The ITC action doesn't end the battle over fuel ethanol imports from Brazil. It comes after only a preliminary hearing and means that the investigation will continue. ITC will look more closely at the question of injury. Meanwhile, the Department of Commerce's International Trade Administration (ITA) will check out the dumping and subsidies issues. Had ITC found no injury or threat of it, the antidumping and countervailing duty cases would have been shelved.

However, with ITC's affirmative vote, the battle will continue. For domestic producers and their farm bloc allies, it is the major assault on import competition. It is, however, only one assault.

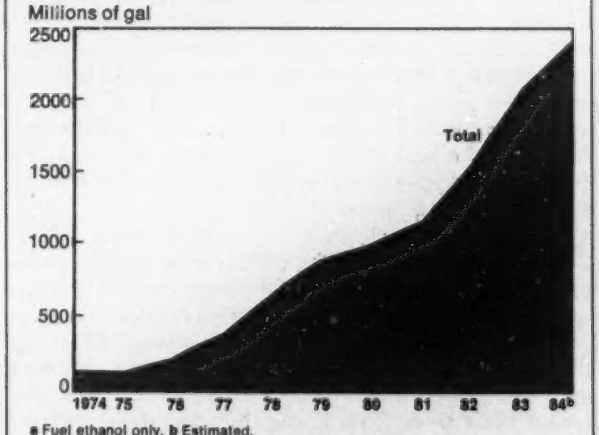
Potentially, large volumes of duty-free fuel ethanol from the Caribbean area also pose a threat to domestic producers. They are maneuvering to meet this threat by petitioning the Customs Bureau for changes in the rules that make duty-free imports from the Caribbean possible. The outcome of this fight could have significant repercussions for one of the Reagan Administration's pet foreign economic aid programs, the Caribbean Basin Initiative.

In addition, the domestic industry wants to close what it says are loopholes in the tariff structure. They claim that imported fuel ethanol is slipping into the country through these loopholes without paying the 60 cent-per-gal duty imposed to protect the fledgling domestic industry. Legislation already has been introduced to plug these loopholes.

The economic stakes are high in this three-front battle—for U.S. producers, for U.S. farmers, and for the U.S. motorist and taxpayer. They are high, too, for those countries, primarily economically strapped developing nations, that are counting on the U.S. fuel ethanol market as a source of much-needed foreign exchange.

Nobody really knows yet just how high those stakes are. The U.S. fuel ethanol market has grown rapidly from virtually nothing in 1978 to a half-billion gal-

Brazil's ethanol production far exceeds that of U.S.



a Fuel ethanol only. b Estimated.
Source: Brazilian Ethanol Producers' Special Export Committee

U.S. producers, farmers accuse Brazil of dumping

The 13 U.S. producers of fuel ethanol and the one farm bureau that filed the antidumping and countervailing duty petitions against Brazilian fuel ethanol imports represent about 69% of domestic production capacity. They are:

- Alcon Industries
- Archer Daniels Midland
- Bio-Chemical Energy
- Byron Elevator Co.
- Graf Feed & Fuel Alcohol
- Grudem Bros. Co.
- KV Alternatives
- Midwest Solvents Co.
- New Energy Co. of Indiana
- Ohio Farm Bureau Development Corp.
- Pekin Energy Co.
- Southern Ethanol
- South Point Ethanol
- A. E. Staley Mfg. Co.

lons last year. Now, two recent Environmental Protection Agency decisions figure to raise the ante. One is EPA's long-expected regulations on phasing out use of lead additives in gasoline. The other is the conditional waiver granted to Du Pont for blends of unleaded gasoline and alcohols. The waiver allows up to 5% methanol and up to 2.5% cosolvents. For fuel ethanol producers, the kick is that, for the first time, ethanol is specified as a possible cosolvent alcohol with methanol.

Market analysts haven't put firm numbers on the potential for fuel ethanol as a result of EPA's decisions. Many consultants are busy trying to do just that. But all agree that the two decisions will increase fuel ethanol demand dramatically.

In addition to the economic issues, all sorts of government policies are involved. It was the government that established the tax subsidies and loan guarantees by which the domestic fuel ethanol industry was created in the first place. Those initiatives came in the late 1970s when the government wanted to develop alternative domestic fuel sources to replace then-scarce and unstable foreign oil supplies.

The government also created the Caribbean Basin Initiative—designed to provide an economic crutch for Caribbean nations and help keep them out of the socialist camp. Meanwhile, the Administration is trying to keep a lid on protectionism. With Brazil, this is a particularly touchy issue. The country already has been hit with several U.S. protectionist moves, and it must export to pay back the billions of dollars it owes, much of it to U.S. banks.

As a result, trade policy and even diplomacy have crept into the picture. The State Department, for instance, has its own study under way on the implications of Brazilian and Caribbean fuel ethanol.

As the battle over fuel ethanol imports heats up, U.S. producers and the farmers that supply them with their raw material (primarily corn) feel that the gods are on their side. They know that Congress initiated the policies that launched the domestic fuel ethanol industry. Hard-pressed farmers are certain that Congress doesn't want to make a bad situation worse for them. And farmers need the markets that fuel ethanol provides.

On the other hand, foreign ethanol suppliers and a handful of supporters in the U.S. believe that they have logic on their side. They contend that if the fuel ethanol market really takes off as expected, U.S. producers won't be able to meet the demand. And they claim that they can produce fuel ethanol more economically, primarily from sugar, than U.S. producers can from corn. Without imports, they say, U.S. taxpayers will have to continue subsidizing a domestic industry that is uncompetitive without the subsidies.

The heavy artillery in the war over fuel ethanol imports is the antidumping and countervailing duty petitions aimed at Brazil. Because of the sheer volumes involved, this is not surprising.

Both petitions were filed by the ad hoc Committee of Domestic Fuel Ethanol Producers. The committee is a group of 13 ethanol-producing companies and the Ohio Farm Bureau Development Corp. Together, they represent 69% of U.S. fuel ethanol capacity.

Despite the number of names on the petition, most observers familiar with the industry believe that Archer Daniels Midland (ADM) is the key player. With about 300 million gal of fuel ethanol capacity, ADM is by far the largest domestic producer. And, according to one outside estimate, ADM controls about 50% of the domestic market. In fact, in responding to the petitions, some Brazilian spokesmen argue that it is ADM, not Brazilian imports, that is the culprit in the U.S. fuel ethanol market.

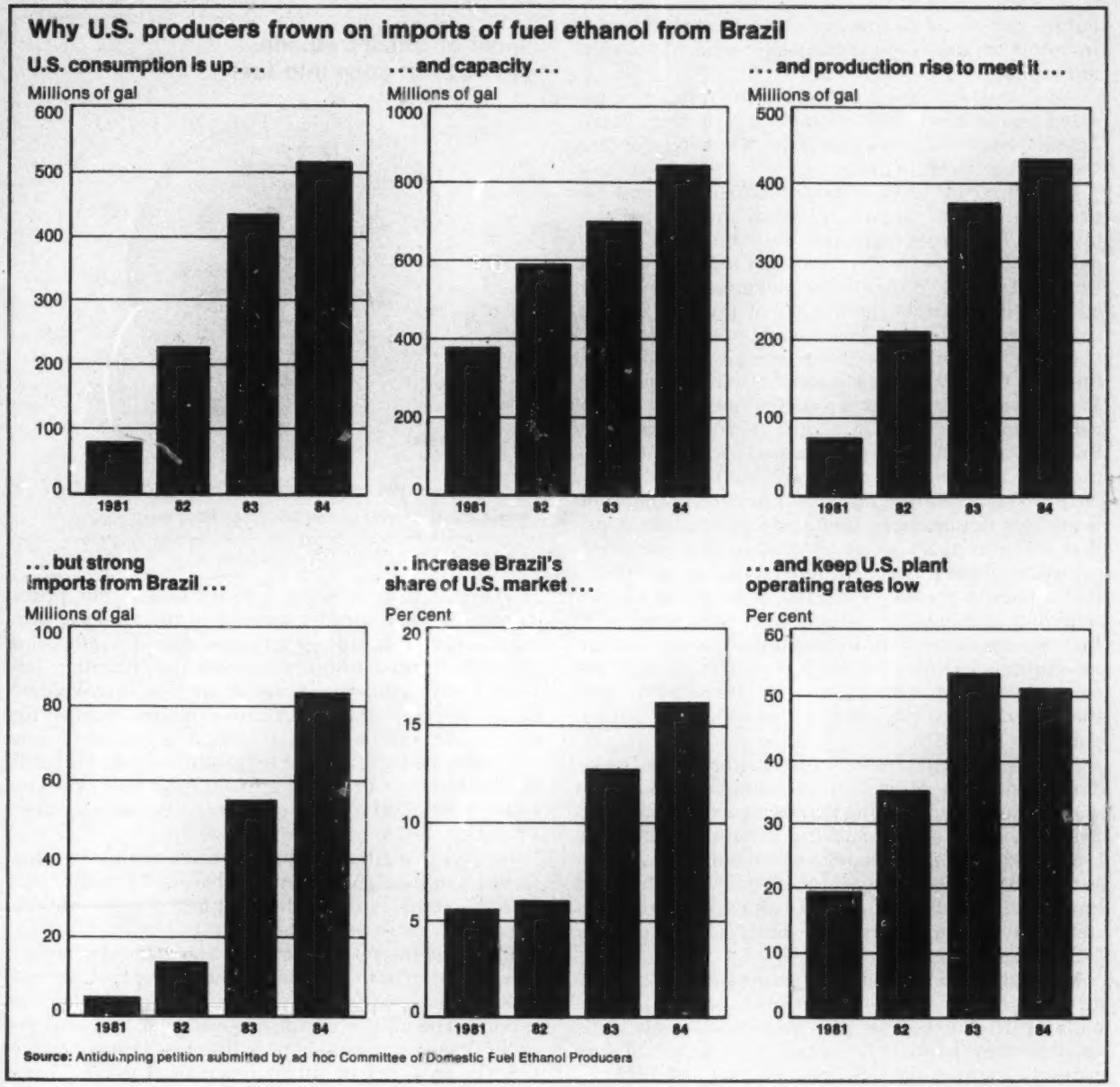
ADM, however, is not the issue in the two petitions. In the antidumping case, the domestic committee charges that Brazilian fuel ethanol is being sold in the U.S. at less than fair value; that is, it's being dumped. The countervailing duty petition claims that the Brazilian government subsidizes producers and exporters of fuel ethanol. Accordingly, U.S. producers want both antidumping penalties and countervailing duties imposed retroactively on Brazilian fuel ethanol imports.

Both ITA and ITC will determine the outcome of the petitions. By law, ITA determines whether dumping and subsidies actually exist. ITC tackles the injury question.

For a country such as Brazil, which is a member of the General Agreement on Tariffs & Trade (GATT), there can be no antidumping or subsidy penalties unless a domestic industry is injured or threatened with injury, or unless imports prevent an industry from being established.

ITC already has ruled that there is a "reasonable indication" that the domestic fuel ethanol industry is "threatened" with injury by Brazilian imports. But this is a preliminary determination based on a preliminary hearing used to screen out frivolous cases. If ITA rules that Brazilian imports are either dumped or subsidized, then ITC will have to make a final decision on injury.

Normally, if injury is found in preliminary hearings, it's also found in the final rulings. But not al-



ways. "There's nothing automatic about it," says one ITC official.

According to the ad hoc committee, the U.S. fuel ethanol industry is being more than injured; it is "facing critical circumstances as a result of unfairly traded Brazilian imports." It says this even though the U.S. market for fuel ethanol, which didn't exist six years ago, has mushroomed to 513 million gal last year.

Now that the lead phasedown regulations are in place and the Du Pont waiver granted, demand for fuel ethanol is certain to become much higher. Estimates vary, but some go as high as 1 billion gal per year by 1990.

The domestic industry has grown along with the market. In 1978, production was a barely discernible 10 million gal. It grew to 75 million gal in 1981 and continued upward to 430 million gal last year. Primarily with the help of government loan guarantees, capacity has been built up to 840 million gal annually, according to the ad hoc committee.

Despite this impressive growth, the ad hoc committee says that the domestic industry is in trouble. Industry operating rates are low—an average 52% of capacity in 1984. Three out of five fuel ethanol plants are shut down. Only 58 of the 145 plants with capacities in excess of 500,000 gal per year were still operating at the end of last year.

The committee claims that domestic producers have lost sales and market share. Many companies are losing money, forcing them to shut down their plants.

Future growth of the industry is jeopardized because investors are becoming increasingly reluctant to commit capital.

All of this, say the petitioners, is the result of subsidized and dumped fuel ethanol imports from Brazil. Brazilian material, they complain, has been flooding the country in record amounts.

On the record, they are right. Official Census figures confirm the growth of Brazilian fuel ethanol imports. They have increased 20-fold, from 4 million gal in 1981 to a hefty 83 million gal last year. Even at this level, Brazilian imports of fuel ethanol have been able to almost triple their share of the U.S. market, from 5.5% in 1981 to 16.2% last year.

But the committee says that the 83 million gal of Brazilian imports last year doesn't tell the whole story. The figure is low, claims the committee. It has "strong reason" to believe that an additional 50 million gal of Brazilian ethanol earmarked for fuel use actually came into the country as industrial-grade ethanol. There is only a 3% ad valorem duty on industrial ethanol imports. But importers of fuel-grade ethanol must pay that 3% plus the special 60 cent-per-gal tariff designed to offset the 60-cent federal excise tax subsidy that domestic producers receive. If Brazilian ethanol imported as industrial material were later diverted to fuel use, importers avoided paying about $25 million in additional duties, at least temporarily, says the committee. It amounts to an interest-free loan from the government until, and if, the additional duty is paid.

John G. Reed Jr., ADM's international vice president, quotes an official of Petrobras, the Brazilian state oil company, as saying that Brazil actually exported 191 million gal of fuel and industrial ethanol to the U.S. last year. Census figures show only 137 million as the 1984 Brazilian import total. "Although the exact figure is in doubt, the effect of Brazilian imports is clear," says Reed, referring to Brazil's huge gain in U.S. market share.

Meanwhile, U.S. producers suspect that an inventory of at least 75 million gal of Brazilian ethanol was built up in the U.S. by the end of last year. This amount, they point out, exceeds total Brazilian fuel ethanol exports to the U.S. between 1981 and 1983.

The committee argues that this buildup of Brazilian fuel ethanol in the U.S. was no accident. It was deliberate, it says. The committee claims that Brazil produced much more fuel ethanol than it consumed last year, leaving the country with a surplus of 528 million gal. Despite this, the government has plans to expand capacity and output of fuel ethanol. Since its heralded Proalcool (national fuel ethanol) program can't soak up this output, the pressure is on to export.

According to the petitioners, Brazil has targeted the U.S. as its principal export market. It wants to export 500 million gal of fuel ethanol to the U.S. this year. That about equals last year's total U.S. consumption.

Brazil's export potential to the U.S. could reach 1.5 billion gal by 1990. Thus, says the committee, "the flood of Brazilian imports has not even crested."

To market its surplus production in the U.S., Brazil is charged with offering fuel ethanol at cut prices only in markets already developed by domestic producers. Lauren L. Hill, general manager of South Point Ethanol, South Point, Ohio, notes that Brazilian imports always seem to be aimed at existing, high-volume customers in states where those imports qualify for state tax incentives. "I have seen no evidence of new customers being converted to [gasoline-ethanol] blends by marketers of Brazilian ethanol, says Hill. And, he adds, "I have seen them offer large volumes of low-priced ethanol to my existing customers."

He says that after building up sales volume in Ohio from 1.1 million gal in January 1984 to 2.3 million gal in May, South Point's sales declined sharply back to 1.2 million gal in September.

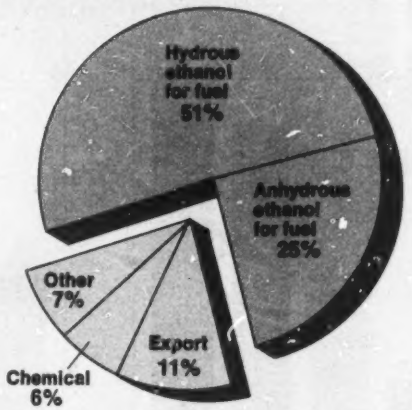
Domestic interests claim that Brazilian imports are able to undercut the market because their fuel ethanol industry is heavily subsidized, from production to exports. The ad hoc committee estimates that importers of Brazilian material are selling fuel ethanol in the U.S. for only 39% of its foreign market value. That's equivalent to a dumping margin of 154%.

South Point's Hill says that his company was forced to cut selling prices 16 cents per gal between January and September last year. But the real telling evidence on prices is contained in the confidential version of the petitions.

Given the corporate relationship between Brazilian exporters and importers, the ad hoc committee charges that importers of Brazilian fuel ethanol must have known about the unfair trading practices. Most Brazilian ethanol is exported by Petrobras Comercio Internacional (Interbras), a subsidiary of Petrobras. And most of the imports come through Internor Trade Inc., of New York City, which is an Interbras subsidiary.

In presenting all of these arguments to ITC and ITA, producers in the U.S. also paint themselves as an emerging industry that is the creation of government

Most of Brazil's ethanol production goes into fuel



1984 consumption = 2 billion gal

Source: Brazilian Ethanol Producers' Special Export Committee

policy. Indeed, it has been nurtured by a wide variety of federal and state economic incentive programs. Among them are investment tax credits, loan guarantees, and federal and state excise and sales tax exemptions for ethanol-containing fuel. "These important expressions of public policy are being thwarted" by massive Brazilian ethanol fuel imports, says the ad hoc committee.

The Brazilians, of course, don't see things quite the same way. They claim that ADM, which "engineered" the petitions against Brazilian fuel ethanol imports to continue its dominance over the U.S. market, is really the villain, not themselves. Rather than hurting the U.S. industry, the Brazilians say that they have helped it in the past and will be even more essential to it in the future.

The basis for their argument is that U.S. producers haven't been able to meet the demand that has developed already and they won't be able to in the future, especially if the market responds to lead additive phaseout as expected. Market growth will depend on adequate and assured supplies of fuel ethanol. U.S. producers, say the Brazilians, haven't been able to offer that, and Brazilian imports have had to take up the slack. Without those imports, some fuel ethanol customers would have switched to other products, they say.

Roger A. Clark, an attorney for Internor, notes that last year U.S. fuel ethanol production fell 137 million gal short of reported U.S. sales. That was not because domestic capacity was underutilized, he argues. "The domestic industry would not and could not have produced any more if there had been no imports last year," Clark says.

Sugarcane could yield 70 million gal of fuel ethanol for export from Brazil's 1985-86 crop year surplus

The reason, he adds, is that there wasn't enough capacity to produce more. When the domestic producers say that they operated at 52% of capacity, they base it on a capacity of 840 million gal per year. Internor says that figure is "way overstated." The Brazilians think that actual capacity was more like 625 million gal. And, after discounting plants that were shut down for a variety of reasons or didn't come on stream until late in the year, effective capacity was even less. The 430 million gal that U.S. companies cranked out was just about as high as they could go, say the Brazilians. Without their imports, there would have been a shortage in the U.S. fuel ethanol market that would have undermined its market acceptance.

Comparing U.S. fuel ethanol production to Brazil's is like comparing Tiny Tim to King Kong. U.S. output last year was 430 million gal. In Brazil it was a staggering 2.5 billion gal. But Brazilian spokesmen insist that they have not flooded the market. Nor do they intend to. In fact, they insist, they are unable to.

Marco Marangoni, export section chief of Petrobras' alcohol marketing division, says that Brazil's Proalcool program was developed to satisfy the Brazilian market and to help make the country self-sufficient in energy. Exports, he says, are secondary.

Statistics that show Brazil's fuel ethanol exports to the U.S. jumping from 4 million gal in 1981 to 83 million in 1984 are accurate. But they don't tell the whole story and can be taken out of context.

In 1980, those exports were 37 million gal. They fell to 4 million gal in 1981 and 13 million gal in 1982, because Brazil either did not have excess ethanol to export or because it could not compete effectively in the U.S. market. In 1983, exports to the U.S. grew to 53 million gal before hitting the 83 million gal last year.

Marangoni says that the surge in exports to the U.S. came late last year for a very good reason. Importers of Brazilian ethanol were trying to beat the 10-cent tariff increase (to 60 cents per gal) that became effective Jan. 1, 1985. Much of these late-arrival imports was put in storage and the inventories are "being sold off in the ordinary course of business."

What's more, Petrobras won't export ethanol to the U.S. this year "in any meaningful amount" until July or August, after the next sugar harvest. Marangoni expects that 70 million gal could be available for export to the U.S. from the 1985-86 crop year surplus. But he wonders if it will be possible to market any Brazilian ethanol in the U.S. in the face of the 60-cent tariff.

Lamartine Navarro Jr. agrees that Brazil isn't in a position to jeopardize U.S. fuel ethanol producers. Navarro, a member of the recently formed Brazilian Ethanol Producers' Special Export Committee and a director of Sopral (an association of Brazilian distillers), says that Brazil is much more concerned with its domestic market than with exports. That market is growing at the rate of 500 million gal per year as ever-more cars designed to run on neat ethanol roll

off Brazilian assembly lines. That annual increase, Navarro points out, amounts to building up an entire industry the size of the U.S. fuel ethanol industry every year.

He warns that unless Brazil makes the necessary plans and investments to supply an export market, the amount of Brazilian ethanol available to meet the anticipated U.S. shortfall will decline. In a very few years, it will disappear. Brazil will not plan or invest until U.S. policy makes it clear that there is a role for Brazilian ethanol to play, he says.

Navarro, like many of his countrymen, thinks that Brazil is being punished because it has a significant cost advantage over U.S. producers of fuel ethanol. He notes that, in the U.S., federal and state tax exemptions amount to a subsidy of at least $1.00 per gal. "That's more than the FOB [free on board] price of Brazilian ethanol," says Navarro.

He concedes that Brazil's Proalcool program was established with government help, just as it was in the U.S. That is, it was subsidized. But the sector now produces ethanol without subsidies. Meanwhile, export subsidies have declined and are scheduled to disappear completely by the end of this month.

U.S. importers of Brazilian ethanol also dismiss the argument that Brazilian product caused the sharp drop in U.S. fuel ethanol prices last year. According to Dean Walcutt, president of Certified Oil, Columbus, Ohio, the real cause was declining gasoline prices coupled with a large and sudden increase in fuel ethanol capacity in the U.S. Midwest.

Certified Oil is the largest private-brand, independent gasoline marketer in Ohio and uses ethanol in almost all of its product. Walcutt buys Brazilian ethanol, but he also buys U.S. product from four companies listed on the antidumping and countervailing duty petitions.

After spelling out the chronology of fuel ethanol and gasoline price cuts in Ohio and other Midwest states for ITC, Walcutt says that Brazilian ethanol imports were not the instigator. In October, New Energy Co. of Indiana opened its plant at South Bend. ADM reopened its Peoria unit. This new capacity, coupled with declining gasoline prices, triggered the price cuts in fuel ethanol, says Walcutt. And, he adds, it was ADM, not the Brazilians, that led the price cutting. The Brazilians "are not the predator," Walcutt says. "They are the predatee." He notes, too, that fuel ethanol prices have gone back up since gasoline prices also have risen.

Brazilian spokesmen charge that the whole fuel ethanol issue raises serious questions about U.S. trade policy and the management of international debt. Navarro says that U.S. protectionism threatens to harm U.S.-Brazilian trade relations. He indicates that the special 60-cent tariff on imported fuel ethanol could lead to trouble for the U.S. among GATT members. And he wonders if the U.S. really wants debtor countries such as Brazil to earn the foreign exchange they need to meet their debt obligations.

Arguments such as these may put pressure on the Reagan Administration, but they shouldn't really matter in antidumping and countervailing duty cases. What does matter are prices, subsidies, and injury.

The injury criteria have been eased to make it easier for domestic industry to prove it. Now imports need not be the only cause of injury, or the principal cause, or the major cause. They don't even have to be a substantial cause. ITC only has to find that imports contribute to injury or the threat of it, as it did in its preliminary ruling.

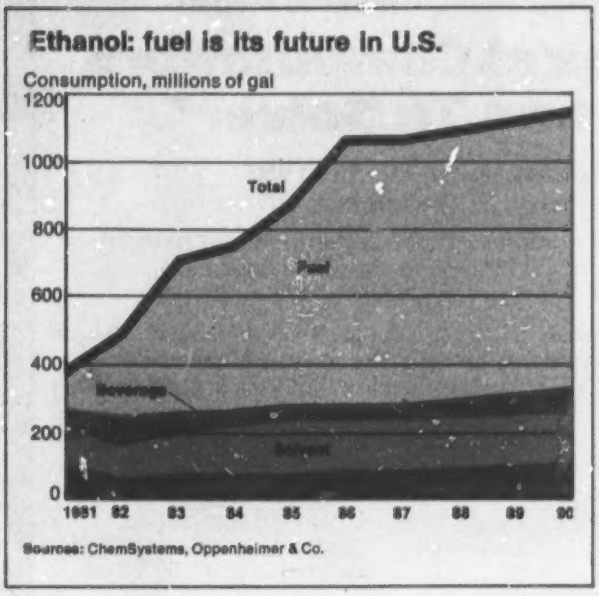
ITC and ITA, however, aren't the only theater of operations in the war over fuel ethanol imports. Customs officials are considering a proposal that could have significant implications for the Caribbean Basin Initiative program.

This petition, filed by the National Corn Growers Association and four others who were also petitioners in the Brazilian cases, seeks to reverse a Customs ruling that allows ethanol that is upgraded to fuel grade in Caribbean countries to enter the U.S. duty free.

Tropicana International, a subsidiary of Tropicana Petroleum, Brea, Calif., recently opened a 20 million gal plant in Jamaica to upgrade "wet" ethanol to "dry," fuel-grade material. Similar projects are planned for Antigua and the Virgin Islands.

U.S. producers claim ethanol that is merely dried in the Caribbean units doesn't deserve duty-free treatment in the U.S. and the maneuver is just an attempt to dodge the 60-cent tariff. The CBI program was initiated to help economically depressed Caribbean countries. It allows imports, with certain exceptions, from eligible countries to come into the U.S. duty free. To prevent abuses, CBI rules say that at least 35%

Cedar Rapids, Iowa, corn wet milling complex of Archer Daniels Midland, by far the largest producer of fuel ethanol in the U.S.



of the product's value must be added in the Caribbean country. And these rules stipulate that the product must be "a new or different article of commerce" (compared to the material from which it is made).

According to U.S. producers, Tropicana's plant in Jamaica and similar planned projects in the Caribbean are essentially "drying operations"—simple distillation units that take wet ethanol from Spain, Brazil, and other countries and remove the water to increase the "proof" of the ethanol. Tropicana insists that its distillation operation is much more sophisticated than that.

Customs has ruled that such ethanol from CBI countries is eligible for duty-free treatment. The domestic petitioners disagree and want the ruling changed. The raw material, they point out, is 150- to 190-proof wet ethanol produced in nonbeneficiary countries such as Spain. It then is dried in a "relatively simple distillation process in CBI countries to 200-proof, fuel-grade ethanol. That hardly represents a "substantial manufacturing process" producing a "new or different article of commerce," they argue.

Once again, the economic and foreign relations stakes are high. The Tropicana project and others like it in the planning stage were initiated with the Customs ruling in mind. A reversal, if it should come, would hit these projects hard.

In Jamaica, most of Tropicana's feedstock is wet ethanol from Spain. Now, it is trying to line up locally produced ethanol. So far, local volumes are small, but the company hopes to use 100% local feedstock in two years.

Domestic producers obviously feel that the economic shoe will be on the other foot if this and future CBI fuel ethanol enter the country duty free. Senate majority leader Robert J. Dole (R.-Kan.) agrees. He has introduced legislation to prevent what he calls "abuse" of the CBI program by Spanish, Brazilian, and other ethanol exporters who are trying to use CBI beneficiary countries to evade U.S. tariffs.

Dole's bill makes it clear that simply distilling or denaturing alcohol does not qualify a product as that of a CBI country. He emphasizes, however, that his bill is not intended to disallow duty-free treatment of ethanol that is a legitimate product of a CBI beneficiary country.

Sen. Dole also has introduced a companion bill to close yet another loophole in U.S. trade laws. The domestic industry has long complained that foreign ethanol producers are exploiting a loophole by mixing their ethanol with gasoline and shipping the blend to the U.S. The duty on gasoline and gasoline blends is 1.25 cents per gal—a far cry from the 60 cents assessed on fuel ethanol. Nobody really knows how much fuel ethanol comes into the U.S. in blends, but the feeling is that it is substantial.

Sen. Dole's bill would make mixtures containing ethanol subject to the 60-cent tariff if they are suitable for fuel use. It also would require that duties be assessed as soon as the imported material enters the country instead of later, when the importer may declare its use as a fuel. This, says the Senator, will prevent imported ethanol from becoming "lost." It also will deprive importers of a possible three-year, interest-free loan amounting to the duties that they owe.

Clearly the battle over fuel ethanol imports is intense. And it may become more intense before it is over. It's more than a question of markets and economics. Government policies and international relationships are inexorably involved. Whether these relationships will play a role in how the various U.S. agencies decide the import issues before them remains to be seen.

Only time will tell if a huge fuel ethanol market will develop in the U.S. as a result of lead additive phasedown and the Du Pont waiver. If it does, only then will everyone know if the U.S. industry will be able to meet the challenge or if imports will be needed to fill the supply-demand gap.

Industry expert David E. Hallberg thinks that imported fuel ethanol has a definite role to play in the U.S. fuels market. A former president of the domestically oriented Renewable Fuels Association, Hallberg is now president of the Washington Energy Trade & Agriculture Group. He stresses that the ethanol fuels industry is entering the second phase of its development just as a series of converging developments present it with major market opportunities.

There's more than a little concern about the life span of some domestic subsidy and loan guarantee programs. This raises the question of how domestic producers will fare without federal and state aid.

For these and other reasons, Hallberg thinks that imported fuel ethanol can fit in, especially in states without tax exemptions. The large marketing niche that this will open up, he says, will benefit all parties—octane-short refiners, U.S. ethanol producers, foreign ethanol producers, methanol producers, and the U.S. motorist. □

Little Growth Ahead For Major Mineral Acids

Slowing in demand will mean continuing overcapacity for sulfuric, rough balance with supply for phosphoric, and changes in trade for both

Bruce F. Greek, C&EN Houston

Stagnating growth in demand this year for major mineral acids—sulfuric and phosphoric—is forcing producers to take a long, hard look at their longer-term prospects. But for the rest of the 1980s, it looks like relatively small net growth for sulfuric acid and somewhat better growth for phosphoric acid.

A slowdown in demand would affect these two acids in distinctly different ways. One significant difference would be a large and continuing overcapacity for sulfuric acid, but a rough balance in supply and demand for phosphoric acid. Another difference might be changes in trade trends, with exports of phosphoric acid rising, on the one hand, and imports of sulfuric acid rising on the other. And various nonfertilizer uses of these acids may be in store, which could mean less dependence of sulfuric acid on phosphoric acid's fortunes.

A slowdown in demand growth this year after a big gain in 1984 was to be expected, especially as the general economic growth also slows. In coming years, forecasts of consumption of these acids become obscured by such uncertainties as export demand, U.S. farm economics, and changes in industrial applications.

Key Chemicals

During recent years of recovery from a severe recession, growth in demand for sulfuric acid has been dominated by its use in making phosphoric acid. The share of sulfuric acid for this use will continue to increase, but more slowly, because other industrial applications will decline, owing to slowing demand for such end products as steel or to such process changes as a shift to the chloride process for making titanium dioxide.

Meanwhile, imports of sulfuric acid are increasing, mainly from Canada. This imported acid often is low-price coproduct smelter acid. Smelter acid is primarily used in metals manufacturing, currently a depressed industry.

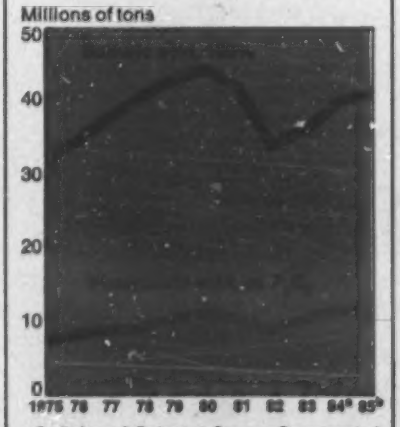
In taking a long-term look at the future of sulfuric acid, producers could be evaluating the economics of shipping the acid from large and newer plants. These plants could be used more fully and have lower unit costs than those of old plants being operated at low rates with high maintenance costs. The result of such studies could be future shutdowns of plants in parts of the U.S. where little or no phosphoric acid is made.

As for phosphoric acid's longer-term outlook, demand for phosphate fertilizers is expected to continue to rise slowly because of efforts to increase yields per acre and to some extent to increase planted acreage despite set-aside programs. Exports of phosphate fertilizers also could remain roughly at current levels or even rise slowly.

The continuing strong export demand has vindicated phosphoric acid producers who built capacity around the beginning of the 1980s. Although no more phosphoric acid capacity is slated for some time, it will be needed before 1990, according to some forecasts, for fertilizer demand.

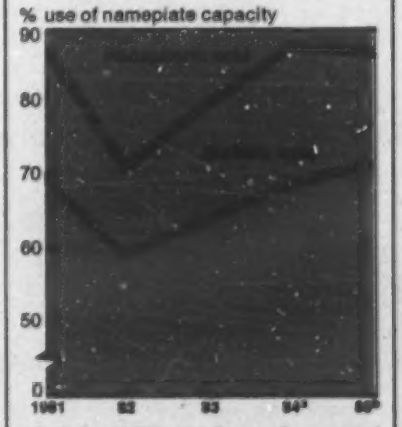
For a more detailed look at the near-term outlook for these acids, please see the following pages.

Phosphoric sets output record, sulfuric still lags



a Preliminary. b Estimated. Sources: Department of Commerce, C&EN estimates

Capacity use of mineral acids recovers well



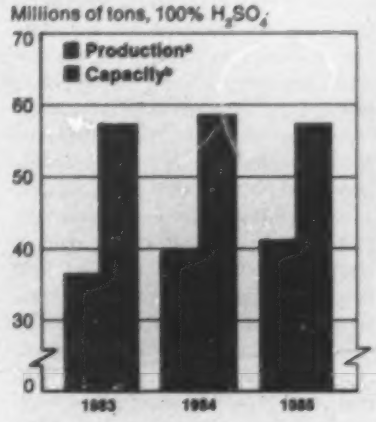
a Preliminary. b Estimated. Sources: Department of Commerce, C&EN estimates

H_2SO_4

Sulfuric acid

- ***Production up modestly***
- ***Capacity off again***
- ***Prices slightly higher***

PRODUCTION/CAPACITY



a From all sources. b First quarter.

MAJOR PRODUCERS

Allied, Du Pont, Monsanto, Olin, Stauffer Chemical

HOW MADE

Sulfur dioxide made by burning sulfur or recovered from smelting, oxidized, and reacted with water

MAJOR DERIVATIVES (U.S.)

None more than 5% of production

MAJOR END USES (U.S.)

Fertilizer manufacturing 70%, metals processing 10%

FOREIGN TRADE

Exports—could rise to 150,000 tons in 1985, imports—remaining around 500,000 tons in 1985

PRICES

List for smelter acid, $20 to $50 per ton; for virgin acid, $55 to $95 per ton

Prospects for sulfuric acid in 1985 are for a further net decline in capacity, a small gain in production if fertilizer and industrial uses are up slightly, and the usual price pressure, minimizing profitability in spite of marketers' best efforts.

Output of sulfuric acid—the largest-volume chemical produced in the U.S. —is expected to increase modestly this year to 41.0 million tons (expressed as 100% product) following a substantial rise in 1984. This slowing of growth is to be expected in a year in which economic expansion has been slowing. But causes of the slowdown this year are more than simply the general level of the economy. They include slowing of exports of phosphate fertilizers, which consume by far the largest share of sulfuric acid.

Actual increase in 1985 sulfuric acid production could be less than 1 million tons of 100% H_2SO_4, or about 2% over 1984 production of 39.9 million tons. However, a small increase is normally expected for such a major-volume product after a large gain in the preceding year. The 1984 production gain was more than 3.4 million tons measured as 100% acid, a 9.3% increase over 1983 output.

Capacity to make sulfuric acid declined during 1984. Part of the net decline of about 500,000 tons came as a result of a shutdown of a major copper smelter, ending its production of by-product acid. Other smelter acid capacity is expected to be either completely shut down or drastically reduced during 1985. Some virgin acid production, going mostly to various industrial uses such as steelmaking, also has been shut down and more will be closed down this year. Offsetting the declines in smelter by-product acid and acid produced for industrial uses will be minor gains in capacity used to make phosphoric acid for fertilizers.

As 1985 began, estimated nameplate capacity to make sulfuric acid from its various sources—including burning of sulfur, recovery from smelter operations, and roasting pyrites—is about 57.5 million tons of 100% acid. Most of this capacity will be available for production during 1985. Thus, the average capacity utilization rate for all plants will be a bit over 71%.

In addition to acid production from the various sources, some 350,000 tons will be added to the supply as a net of imports over exports. The major source of imported sulfuric acid is Canada and much of this is smelter acid (because of pollution regulations, sulfur dioxide can't be released to the atmosphere, and so is converted to sulfuric acid). The major destination of U.S. exports of the acid is Mexico—mostly smelter acid eventually used in diverse small applications such as automobile batteries.

Imported sulfuric acid, most heavily sold from the upper Midwest to the northeastern U.S., keeps pressure on prices for merchant acid. Other price pressure comes from recovered sulfur, which is moved to markets as quickly as possible from desulfurization units at refineries and gas processing plants. The result is a wide range of prices for sulfuric acid.

In 1984, prices for elemental sulfur, especially Frasch sulfur, rose about 17% as three price increases for Frasch sulfur accounted for a total of $25 per long ton, bringing the terminal price at Tampa, Fla., to $147.50 per ton after discounts. Merchant acid prices also rose, but not by this much, because of the large overcapacity. A large gain in phosphate fertilizer exports with accompanying higher prices allowed captive sulfuric acid producers to pass on part of their increased costs of sulfur during 1985.

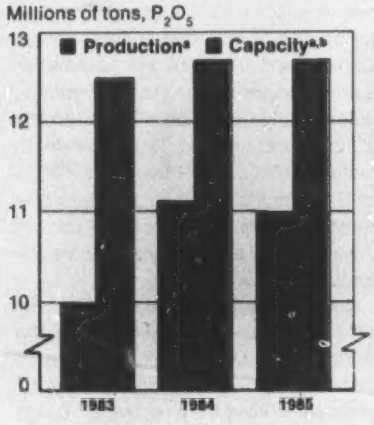
Sulfuric acid's major captive use, some 70% of production, in making phosphoric acid and other fertilizer materials, will not grow much in 1985. The other uses of sulfuric acid, such as in metals processing, petroleum refining, and manufacture of many different chemicals, also will grow slowly this year.

H_3PO_4

Phosphoric acid

- ***Production to slow***
- ***Capacity holding***
- ***Prices poor***

PRODUCTION/CAPACITY



a Wet process and furnace. b First quarter.

MAJOR PRODUCERS

CF Industries, Freeport Chemical, Occidental Chemical, Texasgulf Chemicals, Williams Cos.

HOW MADE

Reaction of phosphate rock with sulfuric acid; burning of elemental phosphorus and subsequent reaction with water

MAJOR DERIVATIVES (U.S.)

Ammonium phosphates 60%, triple superphosphate 15%

MAJOR END USES (U.S.)

Fertilizers 85%, detergent materials 5%

FOREIGN TRADE (as acid)

Exports—holding at about 750,000 tons of P_2O_5 in 1985, imports—below 25,000 tons of P_2O_5 in 1985

PRICES

List about $300 per ton of P_2O_5

Producers of phosphoric acid and its derivatives are watching domestic and export fertilizer markets closely this spring. These swing markets are in a situation similar to that of a year ago when demand had improved. However, export demand for phosphate fertilizers is forecast to weaken later in the year and U.S. fertilizer inventories are expected to be inordinately high.

Slowing fertilizer exports and inventory cutting this summer will cause 1985 output of phosphoric acid to decline about 1% from the 11.1 million tons as P_2O_5 produced in 1984.

Most phosphoric acid (wet acid) is produced by reacting sulfuric acid with phosphate rock that has been processed to increase the concentration of phosphorus in it. A small amount of phosphoric acid (thermal acid) is made by burning elemental phosphorus made in electric furnaces and reacting the P_2O_5 gas with water. Thermal acid accounts for 5 to 10% of total phosphoric acid production, depending on general economic conditions.

If the 1984 production estimate for phosphoric acid holds at 11.1 million tons of P_2O_5 or is revised higher, then it is a new output record. But it will not be much more than the previous high set in 1980 of slightly more than 11 million tons. This year has a chance of being the second highest production year on record.

Even if phosphoric acid production declines more than 1% in 1985, producers will have two good years back to back. The 1984 production was up 11% over 1983, which was devastated by the federal government's payment-in-kind program aimed at reducing crop production. Plant operating rates will average around 87% of nameplate capacity this year, down slightly from 1984.

High plant operating rates have not improved prices for phosphoric acid very much. Some of the sulfur price increases were passed on during 1984 and in early 1985 when U.S. spring fertilizer demand was anticipated to be better after a disappointing fall sales program. Even so, producers' returns haven't changed much as discounts off the list prices for both acid and major derivatives such as diammonium phosphate remain large.

U.S. demand for phosphate fertilizers during 1985 is expected to increase even though financial troubles appear to be widespread among farmers and planted acreage may be down. The scenario includes a spring demand about equal to the strong spring demand of 1984 and a better fall demand than last year. The annual total gain, however, will be small, probably about 300,000 tons of P_2O_5 equivalent.

Some reduction in inventories built last summer will offset the gain in demand for fertilizers and will hold down production over the year. At this time, inventories don't appear to be excessive and interest rates are down. If exports fall as expected this summer, then inventory reduction will follow during the latter part of the third quarter. Plant output will be limited by temporary shutdowns for maintenance.

Exports of phosphate fertilizers and phosphoric acid increased substantially during 1984 to a new high of about 5.2 million tons, as P_2O_5. Inventories were replenished in some major buying countries such as India and were built up to stay ahead of the then-fast-rising value of the dollar. Even with a partial weakening of the dollar now under way, export sales will have to contend with these inventories. As a result, forecasts call for total exports of phosphate this year to be below 1984 exports, possibly amounting to less than 4.7 million tons of P_2O_5, but more likely about 4.9 million tons.

The net difference between the export decline in phosphate fertilizers and the increase in domestic use accounts for the forecast of a slight decline in phosphoric acid production in the U.S. during 1985. Nonfertilizer uses of phosphoric acid are small and will not have any effect on the total production and use.

Urbana dominates graduate rankings

In terms of sheer numbers of new chemistry graduates, 1983–84 was a big academic year for the University of Illinois, Urbana-Champaign, a school long a major force in chemical education. Last year it produced more chemistry graduates with bachelor's degrees than any other institution in the U.S. It produced the highest number of such graduates with degrees certified by the American Chemical Society. And it ranked second in production of new Ph.D. chemists and 19th in the output of masters chemistry graduates.

This is but one of the many facts that can be gleaned from the latest annual report of ACS's Committee on Professional Training (CPT), the group through which the society sets standards for chemistry undergraduate programs and monitors them. The full report starts on page 58.

For nine of the previous 10 years the University of North Carolina, Chapel Hill, had been the largest producer of new bachelor's chemists. But last year it slipped to third as Illinois moved ahead. Indiana University retained the second position it has held since 1980–81.

Illinois, Urbana-Champaign, last year became the fourth school to top the ranking of certified bachelor chemist producers in as many years. It displaced the University of Michigan, which, in turn, had claimed the top spot from Rutgers University. The University of California, San Diego, had headed this list for the eight years ending 1980–81. Certified graduates have completed a curriculum that makes them immediately eligible for ACS membership.

Illinois has been the largest producer of chemistry Ph.D. graduates for eight of the past 11 years. In 1983–84 it was exceeded by the University of California, Berkeley, as it was in both 1979–80 and 1981–82.

The biggest producer of new M.S. graduates last year was the University of Michigan, up from ninth the year before. Cornell University, the leader in 1982–83, slipped to third. □

These schools had the most chemistry graduates, 1983–84

Total bachelor graduates

1. U of Illinois, Urbana-Champaign	139
2. Indiana U	135
3. U of North Carolina, Chapel Hill	129
4. U of California, Los Angeles	116
5. U of Virginia	83
6. Duke U	82
7. U of Miami	81
8. U of Pittsburgh	79
8. U of South Florida	79
10. U of Delaware	71
11. Emory U	69
12. U of Colorado	67
13. U of Maryland, College Park	66
13. Miami U	66
15. Cornell U	60
15. Rutgers U	60
17. California Polytechnic State U	58
17. U of California, Irvine	58
19. U of California, San Diego	57
19. Illinois State U	57
19. State U of New York, Stony Brook	57
19. U of Washington	57
23. U of California, Berkeley	56
24. St. Olaf C	55
25. U of Florida	54
25. U of Puerto Rico	54

Earned bachelor graduates

1. U of Illinois, Urbana-Champaign	65
2. U of California, San Diego	57
3. Illinois State U	55
4. U of California, Berkeley	53
4. U of Michigan	53
6. U of Delaware	51
7. U of Texas	50
8. Rutgers U	43
9. Indiana U	42
10. Massachusetts Inst. of Tech	40
11. U of North Carolina, Chapel Hill	39
12. U of California, Los Angeles	36
13. Purdue U	34
14. U of Washington	31
15. Rensselaer Polytechnic Inst.	30
15. State U of New York, Albany	30
17. U of California, Davis	29
18. Miami U	28
18. Ohio State U	28
20. U of Connecticut	27
20. Cornell U	27
20. San Jose State U	27
20. Virginia Polytechnic Inst.	27
24. U of Minnesota	26
25. Duke U	24
25. C of the Holy Cross	24

Masters graduates

1. U of Michigan	35
2. Northwestern U	32
3. Cornell U	28
3. U of Rochester	28
5. U of Cincinnati	25
6. Yale U	24
7. U of Illinois, Chicago	23
8. Columbia U	21
9. New York U	19
10. Princeton U	18
10. Rensselaer Polytechnic Inst.	18
12. U of Scranton	17
13. U of California, San Diego	16
13. U of Pittsburgh	16
13. U of Washington	16
16. Lawrence U	15
16. U of Maryland, College Park	15
16. Purdue U	15
19. U of Georgia	14
19. U of Illinois, Urbana-Champaign	14
21. U of Massachusetts	13
21. Rutgers U	13
21. U of Texas	13
24. U of Delaware	12
24. Drexel U	12
24. Iowa State U	12
24. U of North Carolina, Chapel Hill	12

Doctoral graduates

1. U of California, Berkeley	62
2. U of Illinois, Urbana-Champaign	52
3. Pennsylvania State U	38
4. Massachusetts Inst. of Tech	36
5. Texas A&M U	35
6. Indiana U	33
7. California Inst. of Tech	31
7. Iowa State U	31
9. U of Minnesota	30
9. Purdue U	30
11. U of California, Los Angeles	29
11. Cornell U	29
13. U of Colorado	27
13. Ohio State U	27
13. U of Wisconsin, Madison	27
16. U of California, San Diego	26
16. U of North Carolina, Chapel Hill	26
18. Harvard U	24
18. U of Maryland, College Park	24
18. Michigan State U	24
21. Yale U	23
22. U of Michigan	21
22. U of Pennsylvania	21
24. U of Delaware	19
24. Princeton U	19

ACS Committee on Professional Training 1984 Annual Report

The number of bachelor's degree graduates in chemistry from colleges and universities whose undergraduate chemistry programs are approved by the American Chemical Society decreased about 2% in the 1983–84 academic year from the previous year. The number of master's degrees from these departments rose 4%, and the number of Ph.D. degrees continued to rise for the fifth year in a row, this year by 1%. These departments project increases for 1986 of 7% for bachelor's degrees, 17% for both master's and Ph.D. degrees. (It should be noted that these projections are usually higher than actual counts a year later.)

The percentage of baccalaureate graduates certified to ACS was 43%, up slightly from the 41 and 42% of previous years. (Certified graduates are those who have completed the curriculum specified by the Committee on Professional Training and are eligible for full membership in ACS; noncertified graduates may become associate members of ACS upon graduation and full members after three years of professional experience or a higher degree in a chemical science.)

A total of 2371 of the bachelor's degree graduates from the approved schools were reported as planning to go to graduate school; 2111, to go to professional schools.

Total numbers of bachelor's degrees, master's degrees, and Ph.D. degrees awarded in 1983–84 by departments whose chemistry programs are ACS approved are listed by institution in the large table at the end of this report and are summarized in the two smaller tables. These tables also include numbers of chemical engineering graduates from institutions whose programs are accredited by the American Institute of Chemical Engineers and the Accreditation Board for Engineering & Technology. (Note: These departments are not required to report their data to CPT, so the number of departments included varies each year.) Included for the third year is a table with information on graduate student enrollments in chemistry departments whose undergraduate programs are ACS approved.

The number of bachelor's degrees in chemical engineering from the 120 AIChE-ABET-accredited departments that reported in 1984 decreased about 2% from the total reported by 122 departments in 1983, the first decrease in this number since 1975. These 120 departments reported an expected further decrease in bachelor's degrees of nearly 4% in 1985. At the graduate level, the number of both chemical engineering master's and Ph.D. degrees increased for the fifth year in a row. The number of master's degrees was up 9% from 1983, and the number of Ph.D.'s was up 7%. Projected increases for 1986 in numbers of master's and Ph.D. degrees in chemical engineering from these schools are 3% and 6%, respectively.

The chemistry programs at ACS-approved schools normally are reevaluated at five-year intervals. There were 580 colleges and universities on the approved list at the end of 1984. During the year, the committee studied the chemistry programs of 161 of the approved schools and of 13 schools applying for ACS approval. Each evaluation involved a review of extensive documentary materials submitted by the department describing the status of the program.

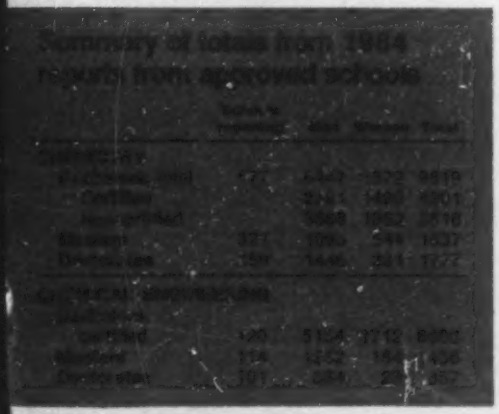
During 1984, 10 schools were added to the ACS-approved list, seven schools were put on probation, two were removed from probation, two were continued on probation, and two schools were removed from the approved list.

In fall 1983, the committee published its revised guidelines for ACS-approved schools. As part of this revision, ACS divisions had been asked to participate in preparing recommendations of the topics that should be covered in an undergrad-

Summary of data from approved schools, 1980–84

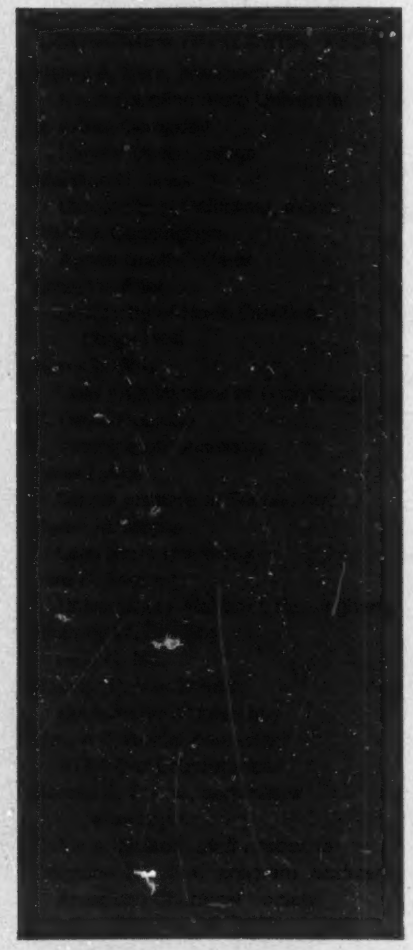
	Bachelors				Masters		Doctorates	
	Number of schools	Graduates (totals)	Certified graduates	Non-certified graduates	Number of schools	Graduates	Number of schools	Graduates
CHEMISTRY								
1980	554	10,170	4170	6000	324	1698	188	1561
1981	558	10,453	4337	6116	323	1609	187	1613
1982	561	9,866	4179	5687	322	1645	187	1683
1983	570	10,043	4233	5810	320	1569	189	1759
1984	577	9,819	4201	5618	321	1637	189	1777
CHEMICAL ENGINEERING[a]								
1980	109	5,348	5348	—	105	974	88	243
1981	110	5,831	5831	—	106	1020	87	250
1982	113	5,963	5963	—	109	1171	92	293
1983	122	7,021	7021	—	116	1317	101	333
1984	120	6,866	6866	—	114	1436	101	357

a Chemical engineering departments are not required to report their data to CPT, so the number of departments included in this category varies from year to year.



uate course in each specialty. Appendix materials were accordingly assembled for analytical chemistry, biochemistry, chemical health and safety, chemical information retrieval, computers in chemistry, industrial chemistry, inorganic chemistry, organic chemistry, and polymer chemistry and sent to the ACS-approved schools in May 1984.

To spread discussion on proposed changes in the guidelines for ACS-approved schools over a period of time and to share thoughts concerned with undergraduate chemical education with the approved schools, the committee decided to prepare and send to the approved schools from time to time position papers on topics of mutual interest. The first two in this series, "Qualitative Organic Analysis Course" and "Advanced Synthesis Laboratory," were sent to the approved schools in fall 1984, and the third, "Biochemistry in the Core Curriculum," was prepared for mailing in January 1985. Comments and suggestions on all three were invited.



Graduate student enrollments in departments whose undergraduate chemistry programs are ACS approved

	Number of departments	First-year graduate students		All graduate students	
		Full time	Part time	Full time	Part time
M.S. departments[a]					
Fall 1981	135	448	366	1,073	1044
Fall 1982	131	494	340	1,076	1042
Fall 1983	132	452	293	1,096	981
Ph.D. departments					
Fall 1981	187	3248	311	12,835	1518
Fall 1982	189	3412	306	13,488	1483
Fall 1983	189	3654	275	14,037	1380

[a] Departments whose highest offering is the master's degree in chemistry.

In an effort to keep abreast of trends in chemical education and to remain current in its understanding of the various needs and situations of the schools on the ACS-approved list, the committee instituted a series of visits by two-person teams from the committee to representative institutions on the approved list. Three visits were made in 1984, and nine more are planned for 1985.

The committee decided to prepare a CPT newsletter to be sent to all chemistry faculty members in four-year colleges and universities in the U.S. and also, for the first issue, to each two-year college chemistry program. The purpose of the newsletter is to highlight issues in chemical education that are currently being discussed by the committee, to provide information on new projects the committee is undertaking, and to invite comments and suggestions concerning CPT-related issues from chemistry faculty members.

Preparation of the DGR Online, a computerized database of all information in the 1983 ACS Directory of Graduate Research as well as a multidimensional concordance of the research interests of the faculty members listed in this edition, continued and was scheduled to be completed in early 1985. The database is available through Bibliographic Retrieval Services. Further information on the file may be obtained from Cathy A. Nelson, ACS Office of Professional Training, 1155—16th St., N.W., Washington, D.C. 20036, telephone (202) 872-4599.

The committee set up a two-year plan for computerizing the data received from the ACS-approved schools. When fully implemented, the new procedure should simplify the way in which departments send updated information on their programs to the committee, facilitate the committee's review of these materials, and provide the chemical education community with a valuable source of data useful in its program planning and evaluation.

A task force to discuss the issue of biochemistry at the undergraduate level was established with representatives from the American Society of Biological Chemists, and CPT representatives were asked to meet with the Panel on Service Courses of the Mathematical Association of America to discuss the nature of the mathematics courses given to chemistry majors.

The committee would like to acknowledge and thank the following visiting associates of the committee who conducted on-site visits to schools on the approved list or applying for ACS approval during 1984: Martin N. Ackermann, Oberlin College; Virgil Boekelheide, University of Oregon; Alan F. Clifford, Virginia Polytechnic Institute & State University; C. Daniel Cornwell, University of Wisconsin; LeRoy Eyring, Arizona State University; Stuart W. Fenton, University of Minnesota; Albert E. Finholt, St. Olaf College; David M. Grant, University of Utah; Donald E. Jones, Western Maryland College; Charles A. Root, Bucknell University; William F. Sager, University of Illinois, Chicago; William H. Saunders, University of Rochester; Barbara R. Shaw, Duke University; Cheves Walling, University of Utah; Robert I. Walter, University of Illinois, Chicago; Theodore R. Williams, College of Wooster.

Chemistry and chemical engineering degrees awarded by approved schools, 1983–84

	CHEMISTRY				CHEMICAL ENGINEERING		
	Bachelor's certified						
	Yes	No	M.S.	Ph.D.	B.S.	M.S.	Ph.D.
Abilene Christian U	6	4	2	—	—	—	—
Adelphi U	6	4	6	1	—	—	—
Agnes Scott C	2	1	—	—	—	—	—
Akron, U of	6	8	8	4	a	—	—
Alabama, U of							
University	2	11	1	6	34	5	1
Birmingham	5	1	3	1	—	—	—
Huntsville	5	6	1	—	—	—	—
Alaska, U of	3	1	0	—	—	—	—
Albion C	2	12	—	—	—	—	—
Albright C	7	17	—	—	—	—	—
Alfred U	5	0	—	—	—	—	—
Allegheny C	1	23	—	—	—	—	—
Alma C	3	9	—	—	—	—	—
American U	6	2	9	7	—	—	—
Amherst C	3	9	—	—	—	—	—
Andrews U	6	11	—	—	—	—	—
Appalachian State U	0	7	0	—	—	—	—
Arizona State U	18	10	2	7	37	10	1
Arizona, U of	7	19	11	14	45	8	1
Arkansas, U of							
Fayetteville	8	3	1	7	39	19	4
Little Rock	3	8	1	—	—	—	—
Ashland C	0	1	—	—	—	—	—
Auburn U	6	38	5	5	91	7	2
Augsburg C	2	13	—	—	—	—	—
Augustana C (Illinois)	1	17	—	—	—	—	—
Augustana C (South Dakota)	3	5	—	—	—	—	—
Austin C	0	10	—	—	—	—	—
Baldwin-Wallace C	2	5	—	—	—	—	—
Ball State U	7	3	2	—	—	—	—
Barnard C	0	13	—	—	—	—	—
Bates C	2	5	—	—	—	—	—
Baylor U	13	15	4	0	—	—	—
Beloit C	2	9	—	—	—	—	—
Bemidji State U	5	7	0	—	—	—	—
Birmingham-Southern C	3	14	—	—	—	—	—
Bloomsburg U	8	1	—	—	—	—	—
Boston C	8	17	6	3	—	—	—
Boston U	0	16	3	4	—	—	—
Bowdoin C	0	37	—	—	—	—	—
Bowling Green State U	8	19	11	—	—	—	—
Bradley U	5	6	0	—	—	—	—
Brandeis U	0	19	11	13	—	—	—
Bridgeport, U of	3	1	8	—	—	—	—
Bridgewater State C	1	9	0	—	—	—	—
Brigham Young U	5	16	2	6	55	6	3
Brown U	0	9	2	16	—	—	—
Bryn Mawr C	19	0	2	2	—	—	—
Bucknell U	15	17	2	—	21	4	—
Butler U	2	6	5	—	—	—	—
California Institute of Tech	10	0	5	31	20	9	11
California Polytechnic State U	16	42	6	—	—	—	—
California State C	—	—	—	—	—	—	—
Bakersfield	6	2	—	—	—	—	—
San Bernardino	0	1	—	—	—	—	—
Stanislaus	1	3	—	—	—	—	—
California State Polytechnic U	9	4	3	—	45	—	—
California State U							
Chico	2	7	—	—	—	—	—
Dominguez Hills	5	5	—	—	—	—	—
Fresno	10	8	7	—	—	—	—
Fullerton	8	16	5	—	—	—	—
Hayward	10	15	1	—	—	—	—
Long Beach	8	25	7	—	56	—	—
Los Angeles	14	0	3	—	—	—	—
Northridge	16	10	3	—	—	—	—
Sacramento	17	4	4	—	—	—	—
California, U of							
Berkeley	53	3	8	62	119	16	26
Davis	29	7	5	16	57	16	2
Irvine	17	41	10	17	—	—	—
Los Angeles	36	80	6	29	13	13	3
Riverside	11	2	9	11	—	—	—
San Diego	57	0	16	25	—	—	—
Santa Barbara	14	8	7	15	a	—	—
Santa Cruz	18	13	8	9	—	—	—
Calvin C	6	9	—	—	—	—	—
Canisius C	11	5	—	—	—	—	—
Capital U	2	8	—	—	—	—	—
Carleton C	3	32	—	—	—	—	—
Carnegie-Mellon U	22	0	10	8	82	4	9
Carroll C	3	7	—	—	—	—	—
Carthage C	3	3	—	—	—	—	—
Case Western Reserve U	7	28	4	9	51	16	2
Catholic U of America	0	2	5	1	a	—	—
Centenary C of Louisiana	0	4	—	—	—	—	—
Central C	0	3	—	—	—	—	—
Central Connecticut State U	10	1	1	—	—	—	—
Central Florida, U of	15	0	6	—	—	—	—
Central Michigan U	2	13	4	—	—	—	—
Central State U (Ohio)	2	2	—	—	—	—	—
Central State U (Oklahoma)	0	10	—	—	—	—	—
Centre C	0	4	—	—	—	—	—
Charleston, C of	2	9	—	—	—	—	—
Chatham C	3	1	—	—	—	—	—
Chestnut Hill C	4	3	—	—	—	—	—
Chicago, U of	9	32	5	13	—	—	—
Cincinnati, U of	22	0	25	17	66	8	4
Citadel, The	1	3	—	—	—	—	—
City U of New York							
Graduate Center	—	—	—	16	—	—	—
Brooklyn College	1	24	3	—	—	—	—
City College	4	11	3	—	a	—	—
Herbert H. Lehman College	5	5	—	—	—	—	—
Hunter College	3	9	—	—	—	—	—
Queens College	4	23	5	—	—	—	—
Clarion U of Pennsylvania	5	1	—	—	—	—	—
Clark U	15	1	3	2	—	—	—
Clarkson U	9	0	9	6	130	19	7
Clemson U	6	2	6	4	66	9	0
Cleveland State U	10	0	7	6	39	10	2
Coe C	0	5	—	—	—	—	—
Colby C	4	7	—	—	—	—	—
Colgate U	1	19	—	—	—	—	—
Colorado C	6	4	—	—	—	—	—
Colorado School of Mines	7	0	4	2	82	14	0
Colorado State U	16	8	0	7	20	10	0
Colorado, U of							
Boulder	18	49	7	27	84	8	2
Colorado Springs	6	4	—	—	—	—	—
Denver	6	16	4	—	—	—	—
Columbia U	4	11	21	18	47	42	7
Concordia C	4	2	—	—	—	—	—
Connecticut, U of	27	9	6	6	60	7	5
Cooper Union[b]	—	—	—	—	29	6	—
Cornell C	0	7	—	—	—	—	—
Cornell U	27	33	28	29	68	19	5
Creighton U	2	31	2	—	—	—	—
Dartmouth C	0	25	1	6	—	—	—
David Lipscomb C	1	19	—	—	—	—	—
Davidson C	8	8	—	—	—	—	—
Dayton, U of	8	8	1	—	a	—	—
Delaware State C	1	2	—	—	—	—	—
Delaware, U of	51	20	12	19	59	14	8
Delaware Valley C of Science & Agriculture	7	0	—	—	—	—	—
Delta State U	0	13	—	—	—	—	—
Denison U	6	3	—	—	—	—	—
Denver, U of	5	12	7	1	—	—	—
De Paul U	1	1	4	—	—	—	—
DePauw U	6	11	—	—	—	—	—
Detroit, U of	5	2	9	4	14	9	—
Dickinson C	9	18	—	—	—	—	—
Drake U	4	6	—	—	—	—	—
Drew U	1	9	—	—	—	—	—
Drexel U	10	1	12	10	86	18	2
Duke U	24	58	4	14	—	—	—
Duquesne U	1	3	6	3	—	—	—
Earlham C	1	12	—	—	—	—	—
East Carolina U	5	5	2	—	—	—	—
East Stroudsburg U	4	13	0	—	—	—	—
East Tennessee State U	7	12	1	—	—	—	—
East Texas State U	1	2	0	—	—	—	—

	CHEMISTRY				CHEMICAL ENGINEERING		
	Bachelor's certified						
	Yes	No	M.S.	Ph.D.	B.S.	M.S.	Ph.D.
Eastern Illinois U	6	8	5	—	—	—	—
Eastern Kentucky U	2	14	1	—	—	—	—
Eastern Michigan U	1	22	7	—	—	—	—
Eastern New Mexico U	1	5	2	—	—	—	—
Eckerd C	3	3	—	—	—	—	—
Elizabethtown C	3	11	—	—	—	—	—
Elmhurst C	3	12	—	—	—	—	—
Emory U	1	68	2	8	—	—	—
Emporia State U	2	9	1	—	—	—	—
Evansville, U of	1	3	—	—	—	—	—
Fairfield U	11	5	—	—	—	—	—
Fairleigh Dickinson U							
Madison	8	7	5	—	—	—	—
Rutherford	2	2	4	—	—	—	—
Teaneck	15	0	4	—	—	—	—
Fisk U	14	0	6	—	—	—	—
Florida Atlantic U	2	14	2	0	—	—	—
Florida Institute of Tech	0	4	0	—	10	0	—
Florida International U	6	10	0	—	—	—	—
Florida State U	7	26	3	10	—	—	—
Florida, U of	8	46	6	17	44	25	3
Fordham U	4	18	4	—	—	—	—
Fort Lewis C	3	9	—	—	—	—	—
Franklin & Marshall C	13	14	—	—	—	—	—
Furman U	11	2	2	—	—	—	—
Geneva C	1	8	—	—	—	—	—
George Mason U	8	7	—	—	—	—	—
George Washington U	7	12	1	5	—	—	—
Georgetown U	14	0	8	7	—	—	—
Georgia Institute of Tech	13	0	6	15	145	28	4
Georgia State U	3	4	3	—	—	—	—
Georgia, U of	6	28	14	16	—	—	—
Gettysburg C	3	6	—	—	—	—	—
Glassboro State C	5	2	—	—	—	—	—
Gonzaga U	1	4	—	—	—	—	—
Goucher C	1	3	—	—	—	—	—
Grand Valley State C	3	13	—	—	—	—	—
Grinnell C	1	18	—	—	—	—	—
Gustavus Adolphus C	4	8	—	—	—	—	—
Hamilton C	0	3	—	—	—	—	—
Hamline U	11	6	—	—	—	—	—
Hampden-Sydney C	9	2	—	—	—	—	—
Hampton Institute	3	4	0	—	—	—	—
Hartford, U of	5	1	0	—	—	—	—
Hartwick C	5	3	—	—	—	—	—
Harvard U	—	29	11	24	—	—	—
Harvey Mudd C	12	0	—	—	—	—	—
Haverford C	4	13	—	—	—	—	—
Hawaii, U of	15	7	2	3	—	—	—
Hiram C	3	6	—	—	—	—	—
Hobart & William Smith C	3	9	—	—	—	—	—
Hofstra U	2	4	—	—	—	—	—
Hollins C	0	1	—	—	—	—	—
Holy Cross, C of the	24	13	—	—	—	—	—
Hope C	14	18	—	—	—	—	—
Houston, U of	13	3	11	15	44	53	6
Howard U	3	25	5	3	19	0	—
Humboldt State U	3	10	—	—	—	—	—
Idaho State U	4	2	0	—	—	—	—
Idaho, U of	6	2	1	2	17	7	1
Illinois Benedictine C	9	0	—	—	—	—	—
Illinois Institute of Tech	1	0	2	2	46	26	4
Illinois State U	55	2	8	—	—	—	—
Illinois, U of							
Chicago	11	29	23	7	40	7	0
Urbana-Champaign	69	70	14	52	105	21	8
Illinois Wesleyan U	3	2	—	—	—	—	—
Indiana State U	6	0	3	—	—	—	—
Indiana U							
Bloomington	42	93	11	33	—	—	—
South Bend	14	10	5	—	—	—	—
Indiana U of Pennsylvania	2	4	—	—	—	—	—
Indiana U-Purdue U							
Fort Wayne	6	4	—	—	—	—	—
Indianapolis	1	28	7	—	—	—	—
Iowa State U	11	5	12	31	72	11	5
Iowa, U of	10	0	10	6	14	8	2
Ithaca C	7	5	—	—	—	—	—
Jackson State U	2	4	3	—	—	—	—
James Madison U	5	9	—	—	—	—	—
John Carroll C	3	15	2	—	—	—	—
Johns Hopkins U	17	0	10	8	19	5	0
Juniata C	5	22	—	—	—	—	—
Kalamazoo C	8	12	—	—	—	—	—
Kansas State U	11	2	2	4	33	7	1
Kansas, U of	14	20	5	8	55	10	2
Kean C of New Jersey	9	2	—	—	—	—	—
Kearney State C	0	6	—	—	—	—	—
Kent State U	6	6	0	5	—	—	—
Kentucky, U of	8	15	3	3	56	15	1
Kenyon C	7	7	—	—	—	—	—
King's C	5	3	—	—	—	—	—
Knox C	2	17	—	—	—	—	—
Lafayette C	7	6	—	—	50	—	—
Lake Forest C	2	10	—	—	—	—	—
Lamar U	10	0	2	—	36	9	0
La Salle C	6	2	—	—	—	—	—
Lawrence Institute of Tech	10	0	—	—	—	—	—
Lawrence U[c]	3	5	15	6	—	—	—
Lebanon Valley C	2	5	—	—	—	—	—
Lehigh U	16	0	10	15	90	31	12
Le Moyne C	10	0	—	—	—	—	—
Lincoln U	1	4	—	—	—	—	—
Long Island U							
Brooklyn Campus	1	3	4	—	—	—	—
C. W. Post C	6	0	—	—	—	—	—
Loras C	2	1	—	—	—	—	—
Louisiana State U							
Baton Rouge	4	9	0	9	65	15	1
Shreveport	2	0	—	—	—	—	—
Louisiana Tech U	2	2	1	—	25	3	0
Louisville, U of	10	19	2	1	—	20	1
Lowell, U of	8	3	3	5	a	—	—
Loyola C	5	2	—	—	—	—	—
Loyola Marymount U	4	0	—	—	—	—	—
Loyola U in New Orleans	1	0	—	—	—	—	—
Loyola U of Chicago	13	16	4	1	—	—	—
Luther C	0	11	—	—	—	—	—
Macalester C	4	3	—	—	—	—	—
Maine, U of	7	4	3	0	38	3	0
Manhattan C[d]	16	2	—	—	52	35	—
Manhattanville C	3	0	—	—	—	—	—
Mankato State U	9	9	—	—	—	—	—
Marietta C	3	2	—	—	—	—	—
Marist C	0	4	—	—	—	—	—
Marquette U	10	0	2	1	—	—	—
Marshall U	8	22	1	—	—	—	—
Maryland, U of							
College Park	17	49	15	24	78	6	2
Baltimore County	10	13	0	0	—	—	—
Massachusetts Institute of Tech	40	0	8	36	111	53	16
Massachusetts, U of	15	5	13	11	56	4	4
McMurry C	0	5	—	—	—	—	—
McNeese State U	1	2	3	—	—	—	—
Memphis State U	1	2	0	3	—	—	—
Mercer U	8	1	—	—	—	—	—
Merrimack C	10	0	—	—	—	—	—
Metropolitan State C	11	4	—	—	—	—	—
Miami U	28	38	3	6	—	—	—
Miami, U of	0	81	0	0	—	—	—
Michigan State U	19	15	10	24	76	13	4
Michigan Technological U	21	0	5	0	101	5	0
Michigan, U of							
Ann Arbor	53	0	35	21	154	20	4
Dearborn	12	7	—	—	—	—	—
Flint	1	6	—	—	—	—	—
Middle Tennessee State U	1	11	1	—	—	—	—
Middlebury C	0	7	0	—	—	—	—
Midwestern State U	2	6	—	—	—	—	—
Millersville U	2	5	—	—	—	—	—
Millsaps C	4	16	—	—	—	—	—
Minnesota, U of							
Minneapolis	26	0	6	30	134	12	15
Duluth	15	8	3	—	—	—	—
Mississippi C	0	10	—	—	—	—	—
Mississippi State U	1	2	0	2	55	4	0
Mississippi, U of	4	9	1	3	24	2	1
Missouri, U of							
Columbia	12	14	5	3	57	8	1
Kansas City	5	13	2	2	—	—	—

	CHEMISTRY				CHEMICAL ENGINEERING		
	Bachelor's certified						
	Yes	No	M.S.	Ph.D.	B.S.	M.S.	Ph.D.
Rolla	10	0	5	0	82	17	2
St. Louis	9	12	5	4	—	—	—
Missouri Western State C	0	1	—	—	—	—	—
Monmouth C (Illinois)	1	10	—	—	—	—	—
Monmouth C (New Jersey)[e]	—	—	—	—	—	—	—
Montana C of Mineral Science & Tech	1	2	1	—	—	—	—
Montana State U	8	5	4	5	59	5	1
Montana, U of	7	4	4	0	—	—	—
Montclair State C	2	12	1	—	—	—	—
Moorhead State U	4	2	—	—	—	—	—
Moravian C	5	4	—	—	—	—	—
Morehouse C[f]	8	8	7	1	—	—	—
Morgan State U	3	5	—	—	—	—	—
Mount Holyoke C	2	8	3	0	—	—	—
Mount Saint Vincent, C of[d]	0	1	—	—	—	—	—
Muhlenberg C	0	25	—	—	—	—	—
Murray State U	3	14	2	—	—	—	—
Muskingum C	5	6	—	—	—	—	—
Nebraska, U of							
Lincoln	8	8	2	10	22	4	—
Omaha	8	6	—	—	—	—	—
Nebraska Wesleyan U	1	3	—	—	—	—	—
Nevada, U of							
Las Vegas	1	4	—	—	—	—	—
Reno	6	4	2	3	—	—	—
New Hampshire, U of	5	9	5	2	38	4	0
New Jersey Institute of Tech[b]	—	—	—	—	92	9	5
New Mexico Highlands U	0	2	2	—	—	—	—
New Mexico Institute of Mining & Tech	10	0	9	—	—	—	—
New Mexico State U	6	9	11	5	28	7	—
New Mexico, U of	6	2	3	8	a	—	—
New Orleans, U of	4	10	1	6	—	—	—
New York U	12	21	19	11	—	—	—
Niagara U	4	7	—	—	—	—	—
North Alabama, U of	2	8	—	—	—	—	—
North Carolina A&T State U	7	0	4	—	—	—	—
North Carolina Central U	2	9	2	—	—	—	—
North Carolina State U	20	10	2	8	132	22	7
North Carolina, U of							
Asheville	1	3	—	—	—	—	—
Chapel Hill	39	90	12	25	—	—	—
Charlotte	1	4	4	—	—	—	—
Greensboro	7	6	3	—	—	—	—
Wilmington	3	11	—	—	—	—	—
North Dakota State U	4	15	5	2	—	—	—
North Dakota, U of	0	3	3	2	23	9	—
North Texas State U	11	7	9	4	—	—	—
Northeast Louisiana U	3	1	4	—	—	—	—
Northeastern Illinois U[e]	—	—	—	—	—	—	—
Northeastern U	7	0	9	7	a	—	—
Northern Arizona U	4	23	3	—	—	—	—
Northern Colorado, U of	2	6	0	0	—	—	—
Northern Illinois U	6	12	8	5	—	—	—
Northern Iowa, U of	5	20	0	—	—	—	—
Northern Kentucky U	4	4	—	—	—	—	—
Northern Michigan U	0	7	0	—	—	—	—
Northwest Missouri State U	4	3	—	—	—	—	—
Northwestern State U of Louisiana	0	1	—	—	—	—	—
Northwestern U	11	17	32	17	47	19	12
Norwich U	0	0	—	—	—	—	—
Notre Dame, U of	7	11	4	10	65	8	2
Oakland U	11	3	0	—	—	—	—
Oberlin C	0	28	—	—	—	—	—
Occidental C	8	7	—	—	—	—	—
Ohio Northern U	2	4	—	—	—	—	—
Ohio State U	28	0	9	27	86	29	3
Ohio U	6	5	5	4	24	7	0
Ohio Wesleyan U	0	6	—	—	—	—	—
Oklahoma State U	7	7	2	7	42	9	6
Oklahoma, U of	12	30	9	2	72	13	3
Old Dominion U	8	3	9	—	—	—	—
Oregon State U	8	0	4	8	45	4	0
Oregon, U of	10	24	7	12	—	—	—
Pace U	1	4	—	—	—	—	—
Pacific Lutheran U	5	9	—	—	—	—	—
Pacific, U of the	4	12	1	0	—	—	—
Pennsylvania State U	14	12	4	38	178	19	5
Pennsylvania, U of	11	33	3	21	65	15	8
Philadelphia C of Pharmacy & Science	9	0	4	2	—	—	—
Philadelphia C of Textiles & Science	1	0	—	—	—	—	—
Pittsburg State U	2	3	2	—	—	—	—
Pittsburgh, U of	8	71	16	12	56	11	1
Polytechnic Institute of New York	3	0	6	11	45	12	6
Pomona C	7	7	—	—	—	—	—
Portland State U	1	11	3	2	—	—	—
Pratt Institute[b]	—	—	—	—	12	—	—
Princeton U	9	11	18	19	23	6	8
Providence U	7	4	0	0	—	—	—
Puerto Rico, U of							
Mayaguez	21	0	2	—	69	3	—
Rio Piedras	21	33	2	4	—	—	—
Puget Sound, U of	8	0	—	—	—	—	—
Purdue U	34	16	15	30	164	15	15
Purdue U Calumet	1	4	—	—	—	—	—
Randolph-Macon Woman's C	1	2	—	—	—	—	—
Redlands, U of	1	1	—	—	—	—	—
Reed C	10	3	—	—	—	—	—
Regis C	2	5	—	—	—	—	—
Rensselaer Polytechnic Institute	30	0	18	9	103	19	2
Rhodes C (formerly Southwestern, Memphis)	4	2	—	—	—	—	—
Rhode Island, U of	7	3	7	4	31	7	1
Rice U	3	1	10	10	38	11	6
Richmond, U of	0	11	0	—	—	—	—
Rider C	6	0	—	—	—	—	—
Ripon C	2	4	—	—	—	—	—
Roanoke C	5	3	—	—	—	—	—
Rochester Institute of Tech	10	18	11	—	—	—	—
Rochester, U of	10	7	28	11	50	11	2
Rollins C	1	0	—	—	—	—	—
Roosevelt U	5	0	7	—	—	—	—
Rose-Hulman Institute of Tech	7	0	—	—	a	—	—
Russell Sage C	5	0	—	—	—	—	—
Rutgers U							
Camden C	2	7	—	—	—	—	—
New Brunswick	45	15	13	14	104	15	5
Newark C of Arts & Sciences	14	14	3	6	—	—	—
Saginaw Valley State C	1	11	—	—	—	—	—
St. Anselm C	5	3	—	—	—	—	—
St. Catherine, C of	2	4	—	—	—	—	—
St. Cloud State U	4	4	—	—	—	—	—
St. John Fisher C	4	1	—	—	—	—	—
St. John's U	10	1	2	—	—	—	—
St. John's U/C of St. Benedict[e]	—	—	—	—	—	—	—
St. Joseph C	3	2	6	—	—	—	—
St. Joseph's U	3	18	7	—	—	—	—
St. Lawrence U	7	18	—	—	—	—	—
St. Louis U	12	31	2	—	—	—	—
St. Mary's C	2	12	—	—	—	—	—
St. Michael's C	0	3	—	—	—	—	—
St. Olaf C	6	49	—	—	—	—	—
St. Peter's C	3	6	—	—	—	—	—
St. Thomas, C of	4	6	—	—	—	—	—
Salem State C	2	0	—	—	—	—	—
Sam Houston State U	9	1	4	—	—	—	—
San Diego State U	16	2	10	2	—	—	—
San Francisco State U	5	29	4	—	—	—	—
San Francisco, U of	3	7	1	—	—	—	—
Sangamon State U	1	1	—	—	—	—	—
San Jose State U	27	10	9	—	17	7	—
Santa Clara, U of	3	9	—	—	—	—	—
Scranton, U of	11	12	17	—	—	—	—
Seattle U	1	10	—	—	—	—	—
Seton Hall U	6	3	11	6	—	—	—
Shippensburg U	8	3	1	—	—	—	—
Siena C	7	2	—	—	—	—	—
Simmons C	5	4	—	—	—	—	—
Skidmore C	4	15	—	—	—	—	—
Smith C	9	0	1	0	—	—	—
Sonoma State U	1	9	—	—	—	—	—
South Carolina, U of	6	16	2	18	42	7	0
South Dakota School of Mines & Tech	8	0	4	—	38	9	—

	CHEMISTRY				CHEMICAL ENGINEERING		
	Bachelor's certified						
	Yes	No	M.S.	Ph.D.	B.S.	M.S.	Ph.D.
South Dakota State U	4	19	3	—	—	—	—
South Dakota, U of	6	9	0	—	—	—	—
South Florida, U of	13	66	2	4	48	4	0
Southeast Missouri State U	0	7	—	—	—	—	—
Southeastern Louisiana U	0	3	—	—	—	—	—
Southeastern Massachusetts U	8	2	0	—	—	—	—
Southern California, U of	13	9	6	14	a	—	—
Southern Colorado U	1	6	—	—	—	—	—
Southern Illinois U							
Carbondale	5	13	3	3	—	—	—
Edwardsville	13	3	2	—	—	—	—
Southern Methodist U	7	12	1	—	—	—	—
Southern Mississippi, U of	1	12	1	3	—	—	—
Southern Oregon State C	2	7	—	—	—	—	—
Southern U & A&M C	8	0	0	—	—	—	—
Southwest Missouri State U	5	21	—	—	—	—	—
Southwest State U	4	5	—	—	—	—	—
Southwest Texas State U	20	4	0	—	—	—	—
Southwestern Louisiana, U of	0	16	2	—	a	—	—
Southwestern Oklahoma State U	7	2	—	—	—	—	—
Stanford U	12	19	2	15	34	36	9
State U of New York							
Albany	30	1	2	3	—	—	—
Binghamton	11	25	10	5	—	—	—
Buffalo	19	9	5	7	93	23	5
Stony Brook	20	37	3	17	—	—	—
C at Brockport	6	1	—	—	—	—	—
C at Buffalo	3	7	2	—	—	—	—
C at Cortland	3	6	—	—	—	—	—
C at Fredonia	9	2	4	—	—	—	—
C at Geneseo	8	2	0	—	—	—	—
C at New Paltz	7	4	4	—	—	—	—
C at Oneonta	1	25	0	—	—	—	—
C at Oswego	16	4	4	—	—	—	—
C at Plattsburgh	8	20	1	—	—	—	—
C at Potsdam	0	12	—	—	—	—	—
Stephen F. Austin State U	4	3	1	—	—	—	—
Stetson U	3	5	—	—	—	—	—
Stevens Institute of Tech	9	0	9	2	—	—	—
Suffolk U	2	3	—	—	—	—	—
Susquehanna U	1	7	—	—	—	—	—
Swarthmore C	3	10	—	—	—	—	—
Syracuse U	15	5	4	5	a	—	—
Temple U	7	4	3	4	—	—	—
Tennessee Technological U	3	22	2	—	29	8	0
Tennessee, U of							
Knoxville	3	23	6	9	85	17	9
Martin	1	5	—	—	—	—	—
Chattanooga	13	7	—	—	—	—	—
Texas A&I U	6	0	4	—	a	—	—
Texas A&M U	16	11	10	35	139	17	2
Texas Christian U	3	9	0	3	—	—	—
Texas Southern U	21	0	6	—	—	—	—
Texas Technological U	14	7	7	9	43	11	1
Texas, U of							
Arlington	10	9	1	2	—	—	—
Austin	50	0	13	16	101	28	6
Dallas	6	0	2	—	—	—	—
El Paso	6	0	10	—	—	—	—
Texas Woman's U	1	2	2	0	—	—	—
Thiel C	4	4	—	—	—	—	—
Thomas More C	1	1	—	—	—	—	—
Toledo, U of	5	9	0	0	24	4	0
Towson State U	3	7	—	—	—	—	—
Trenton State C	15	0	—	—	—	—	—
Trinity C	12	4	0	—	—	—	—
Trinity U	6	6	0	—	—	—	—
Tri-State U[b]	—	—	—	—	16	—	—
Tufts U	2	19	1	4	33	3	0
Tulane U of Louisiana	2	12	1	2	33	8	0
Tulsa, U of	2	0	—	—	33	12	2
Tuskegee Institute	0	2	3	—	f	—	—
Union C	7	12	—	—	—	—	—
U.S. Air Force Academy	12	1	—	—	—	—	—
U.S. Naval Academy	18	1	—	—	—	—	—
Ursinus C	4	20	—	—	—	—	—
Utah State U	9	0	4	5	—	—	—
Utah, U of	6	27	3	8	a	—	—
Valparaiso U	3	33	—	—	—	—	—
Vanderbilt U	1	18	3	4	44	5	0
Vassar C	2	6	0	—	—	—	—
Vermont, U of	19	0	0	5	—	—	—
Villanova U	11	0	8	5	30	6	—
Virginia Commonwealth U	9	11	5	2	—	—	—
Virginia Military Institute	12	0	—	—	—	—	—
Virginia Polytechnic Institute & State U	27	10	5	12	77	12	2
Virginia, U of	11	72	5	10	41	26	2
Wabash C	10	5	—	—	—	—	—
Wagner C	0	3	—	—	—	—	—
Wake Forest U	5	16	0	0	—	—	—
Washburn U of Topeka	0	4	—	—	—	—	—
Washington C	2	0	—	—	—	—	—
Washington & Jefferson C	2	29	—	—	—	—	—
Washington & Lee U	1	13	—	—	—	—	—
Washington State U	7	10	7	16	34	13	0
Washington U	5	12	8	10	69	15	2
Washington, U of	31	26	16	11	80	12	4
Wayne State U	20	14	6	15	42	20	1
Waynesburg C	5	2	—	—	—	—	—
Weber State C	6	4	—	—	—	—	—
Wellesley C	5	31	—	—	—	—	—
Wesleyan U	3	21	1	5	—	—	—
West Chester U	6	12	2	—	—	—	—
West Florida, U of	13	2	—	—	—	—	—
West Texas State U	1	13	0	—	—	—	—
West Virginia Institute of Tech	2	1	—	—	20	0	—
West Virginia State C	3	7	—	—	—	—	—
West Virginia U	10	39	9	4	41	7	0
Western Illinois U	18	5	2	—	—	—	—
Western Kentucky U	9	18	8	—	—	—	—
Western Maryland C	1	11	—	—	—	—	—
Western Michigan U	3	12	4	1	—	—	—
Western New England C	5	0	—	—	—	—	—
Western Washington U	13	10	3	—	—	—	—
Westminster C	0	8	—	—	—	—	—
Wheaton C (Illinois)	3	13	—	—	—	—	—
Wheaton C (Massachusetts)	7	6	—	—	—	—	—
Wheeling C	0	1	—	—	—	—	—
Whitman C	6	10	—	—	—	—	—
Whittier C	1	2	—	—	—	—	—
Wichita State U	6	11	6	1	—	—	—
Widener U	1	0	—	—	—	—	—
Wilkes C	4	3	—	—	—	—	—
Willamette U	2	10	—	—	—	—	—
William Paterson C of New Jersey	0	2	—	—	—	—	—
William & Mary, C of	18	5	2	—	—	—	—
Williams C	1	35	—	—	—	—	—
Wisconsin, U of							
Eau Claire	11	5	—	—	—	—	—
Green Bay	0	5	—	—	—	—	—
La Crosse	2	4	—	—	—	—	—
Madison	16	33	8	27	131	13	7
Milwaukee	3	12	8	4	—	—	—
Oshkosh	10	3	3	—	—	—	—
Parkside	5	10	—	—	—	—	—
Platteville	1	2	—	—	—	—	—
River Falls	6	12	—	—	—	—	—
Stevens Point	4	11	—	—	—	—	—
Superior	2	2	—	—	—	—	—
Wittenberg U	3	5	—	—	—	—	—
Wooster, C of	3	25	—	—	—	—	—
Worcester Polytechnic Institute	2	4	0	0	66	7	2
Wright State U	20	8	9	—	—	—	—
Wyoming, U of	4	2	2	7	20	4	0
Xavier U	3	9	1	—	—	—	—
Xavier U of Louisiana	2	25	—	—	—	—	—
Yale U	8	1	24	23	a	—	—
Youngstown State U	3	33	3	—	32	—	—
TOTALS	**4201**	**5618**	**1637**	**1777**	**6866**	**1436**	**357**

a Data not submitted. b Listed on basis of accreditation by AIChE-ABET. c Master's and Ph.D. degrees given by the Institute of Paper Chemistry. d The chemistry programs at Mount Saint Vincent College and Manhattan College are integrated into a combined department with all instruction in chemistry located at Manhattan College. e Added in 1984. f Master's degrees given by Atlanta University. **Note:** For brevity, B.S. and M.S. are used to denote all bachelor's and master's degrees, respectively, in each column.